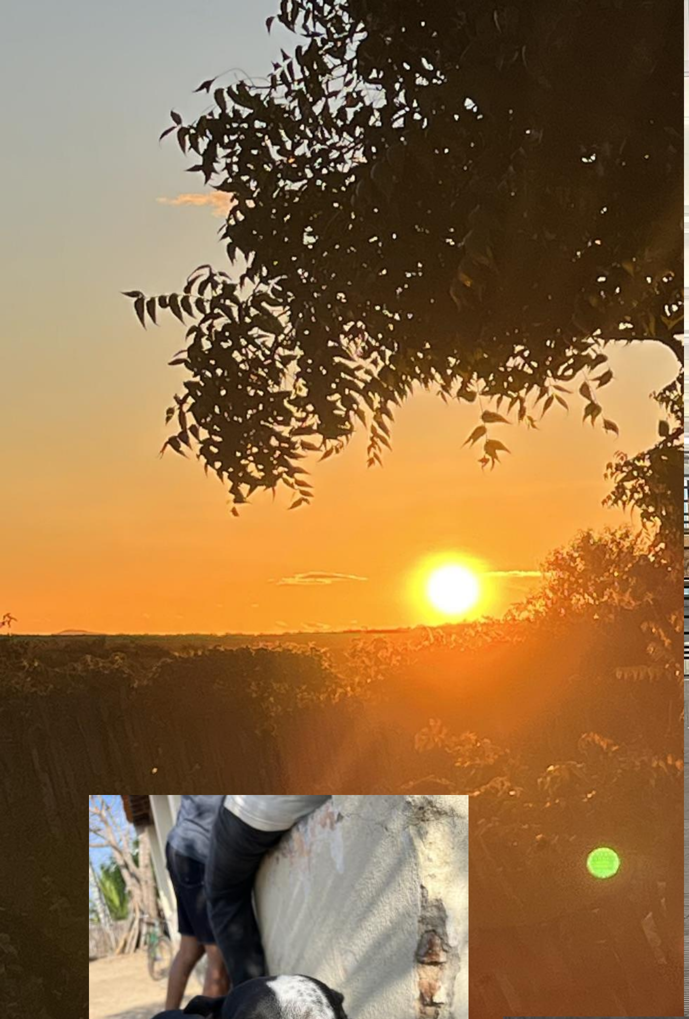
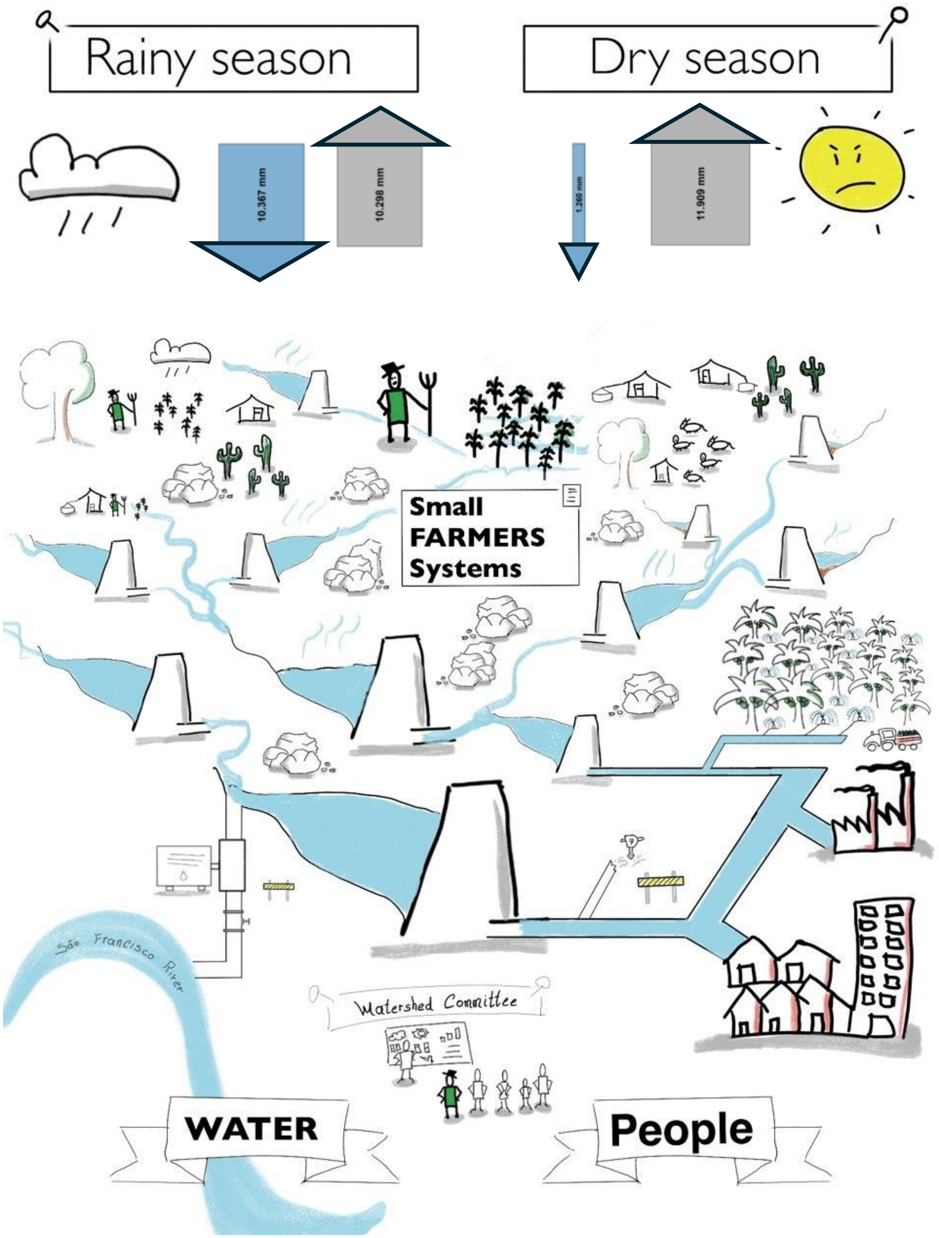
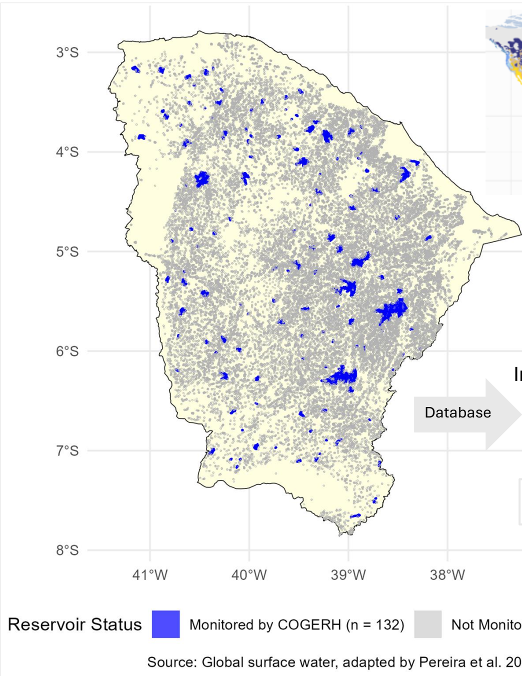


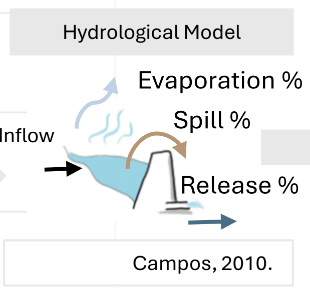
Dead Child (1944), by Candido Portinari, portrays the human suffering caused by drought, poverty, and displacement in Brazil.

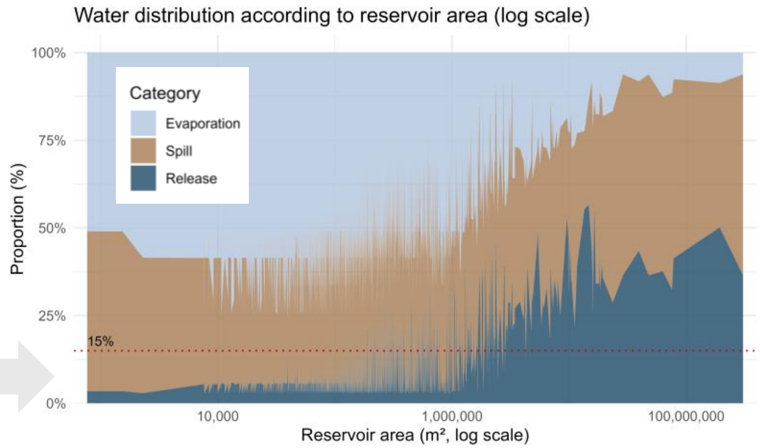
Reservoir classification based on hydrological efficiency to improve water governance in the drylands

Camila Lira, Pedro Medeiros and Eva Paton





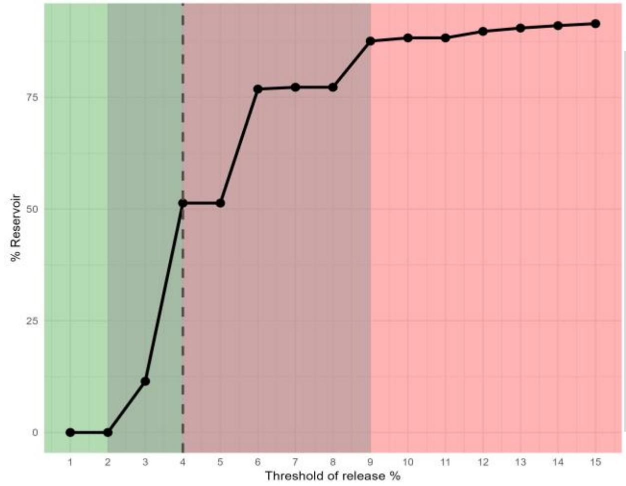




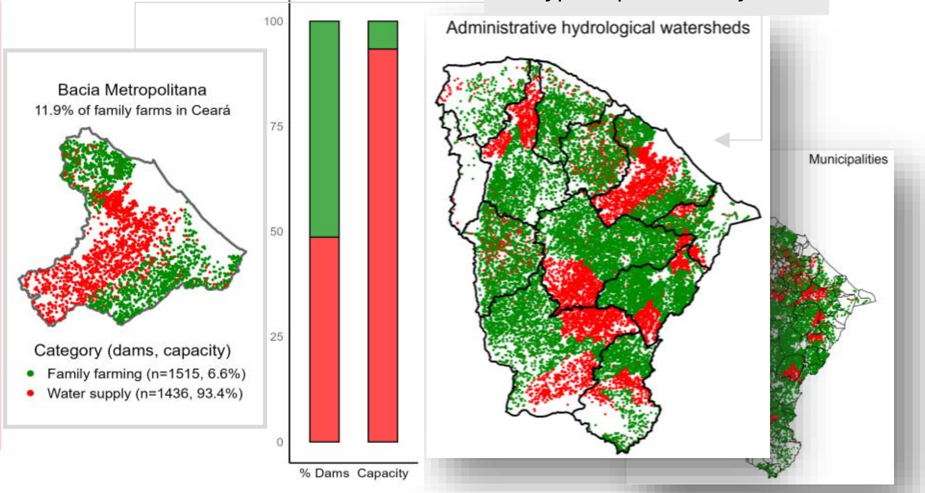
Smaller reservoirs
Lower efficiency

Larger reservoirs
High efficiency

Spatial classification of reservoirs

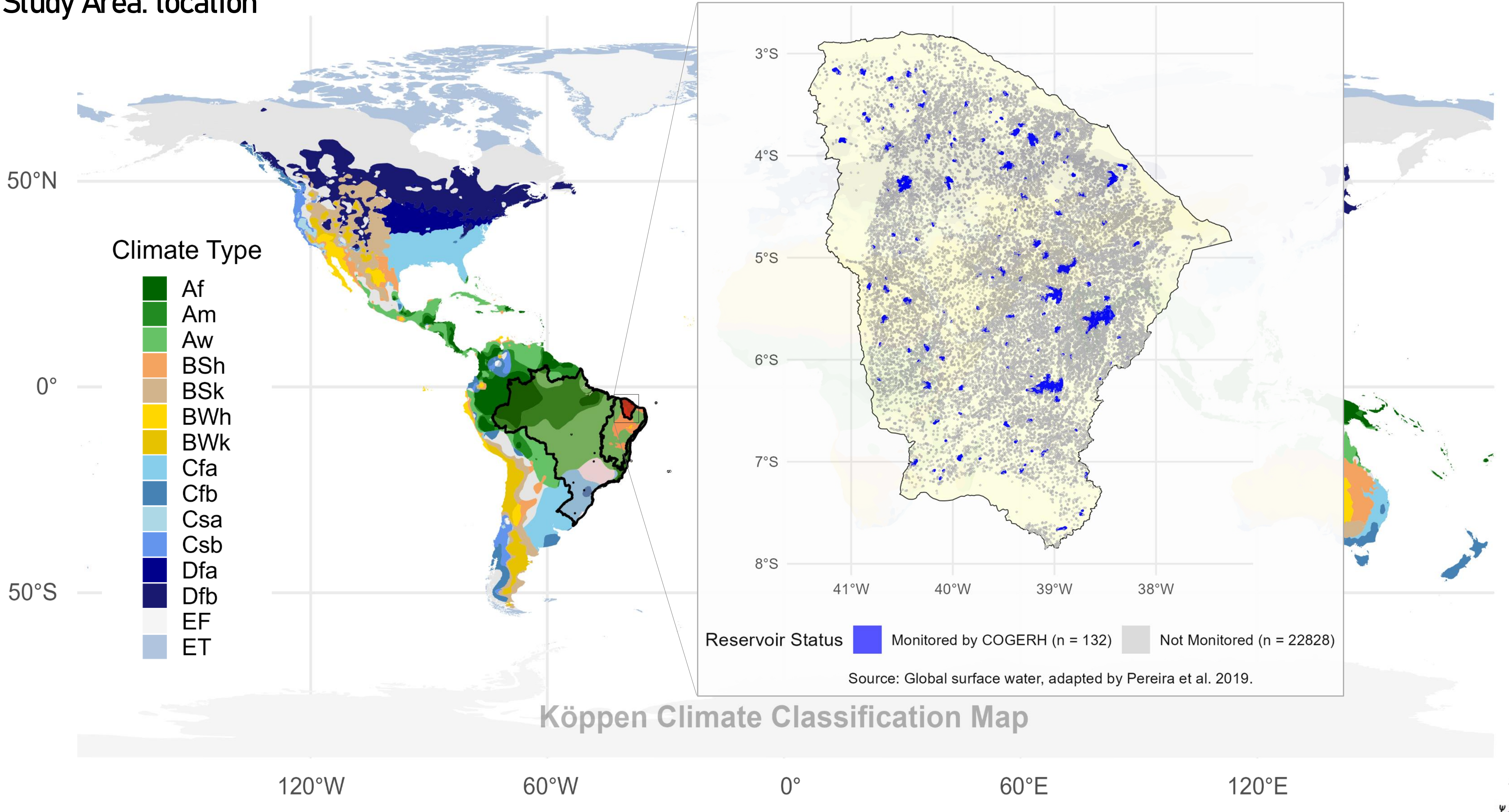


Types spatial analysis



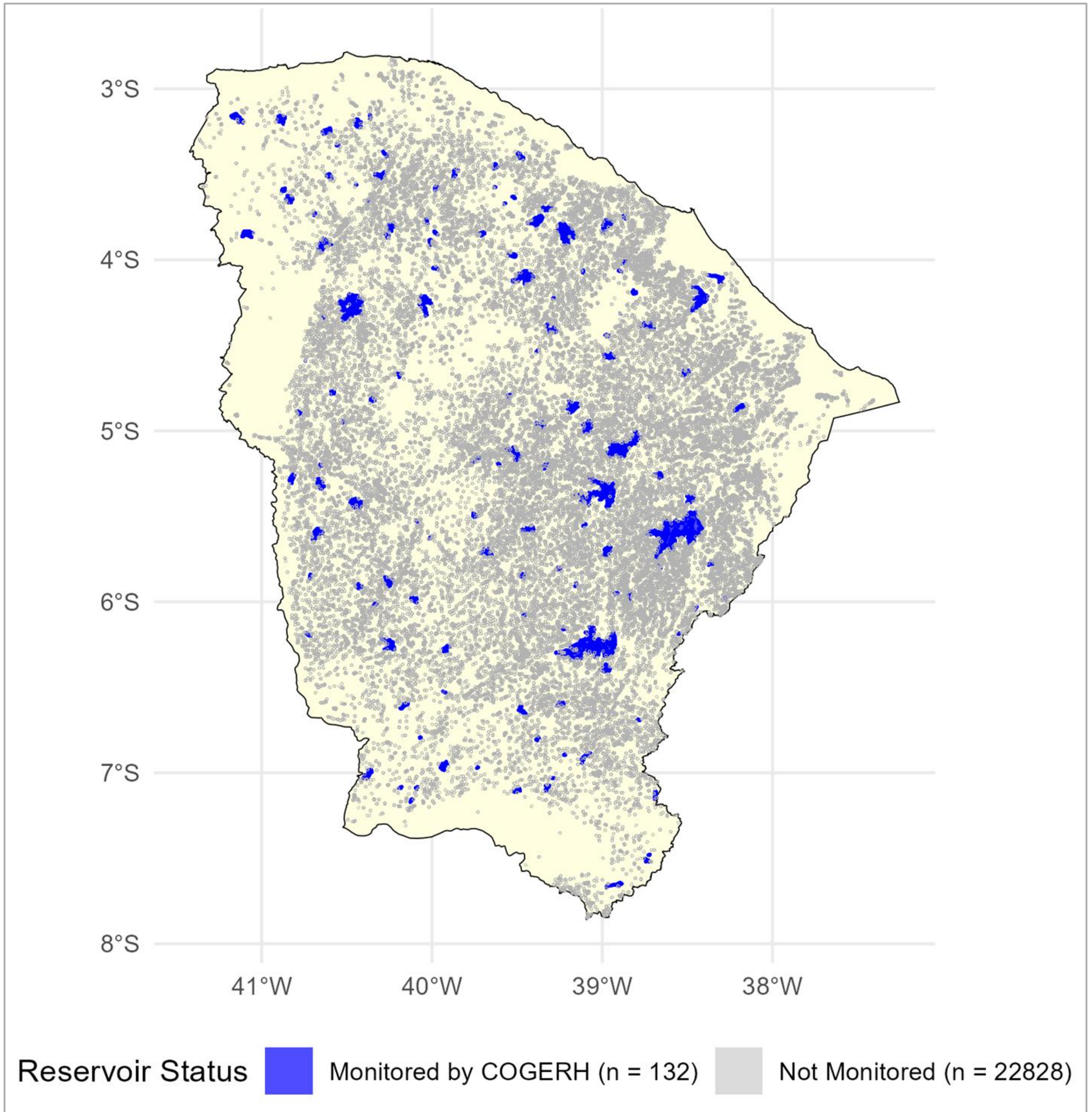
Author: Lira, C. C. S.

Study Area: location

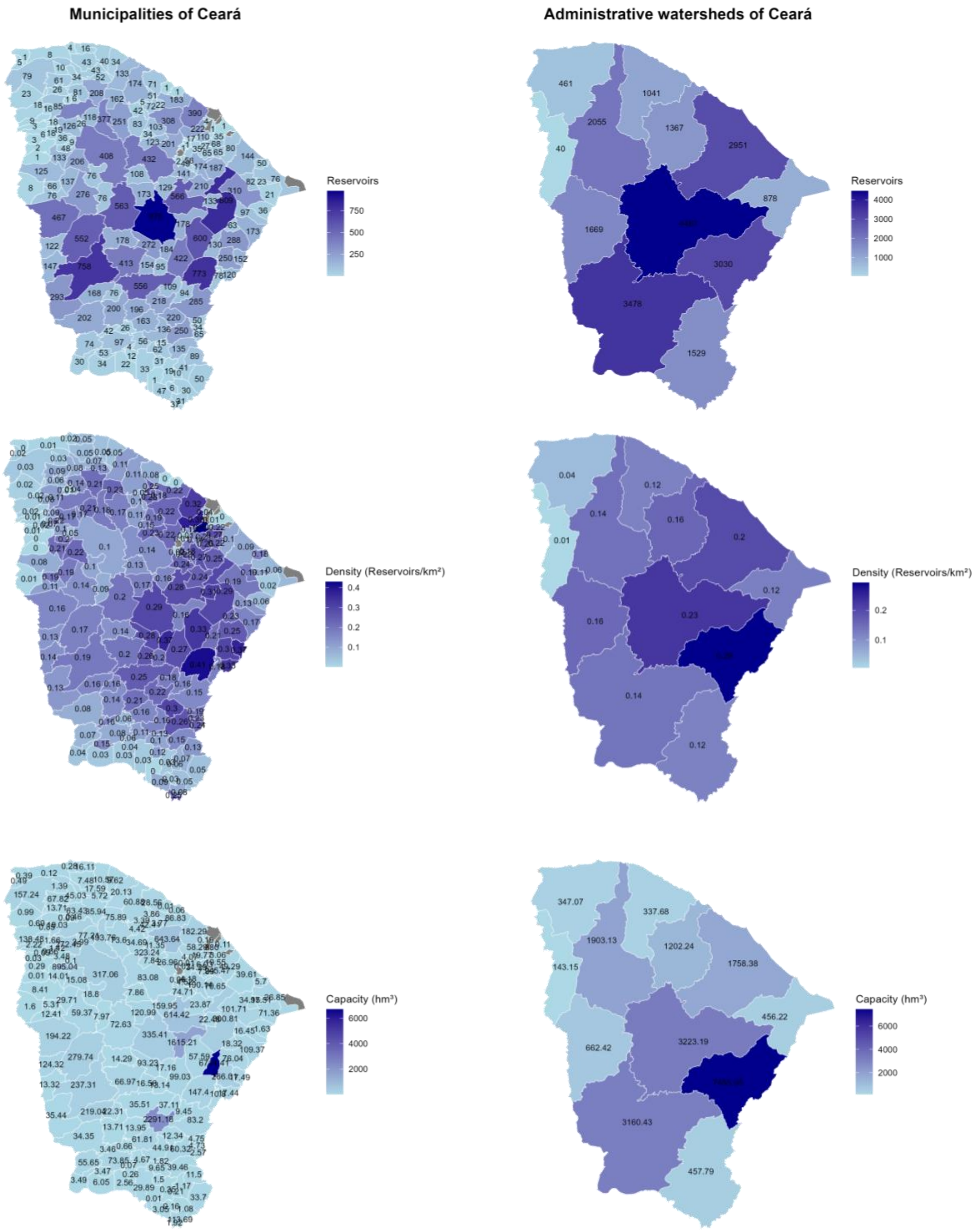


Author: Lira, C. C. S.

Study Area: Summary Ceará’s reseroir network

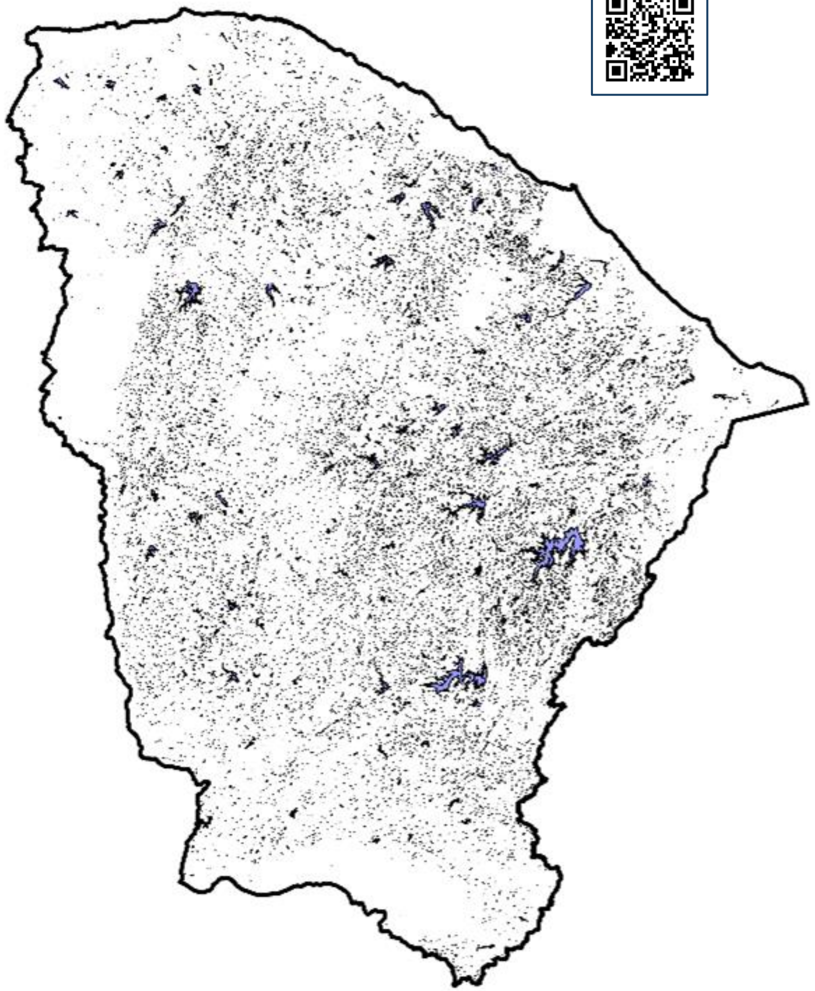


Source: Global surface water, adapted by Pereira et al. 2019.



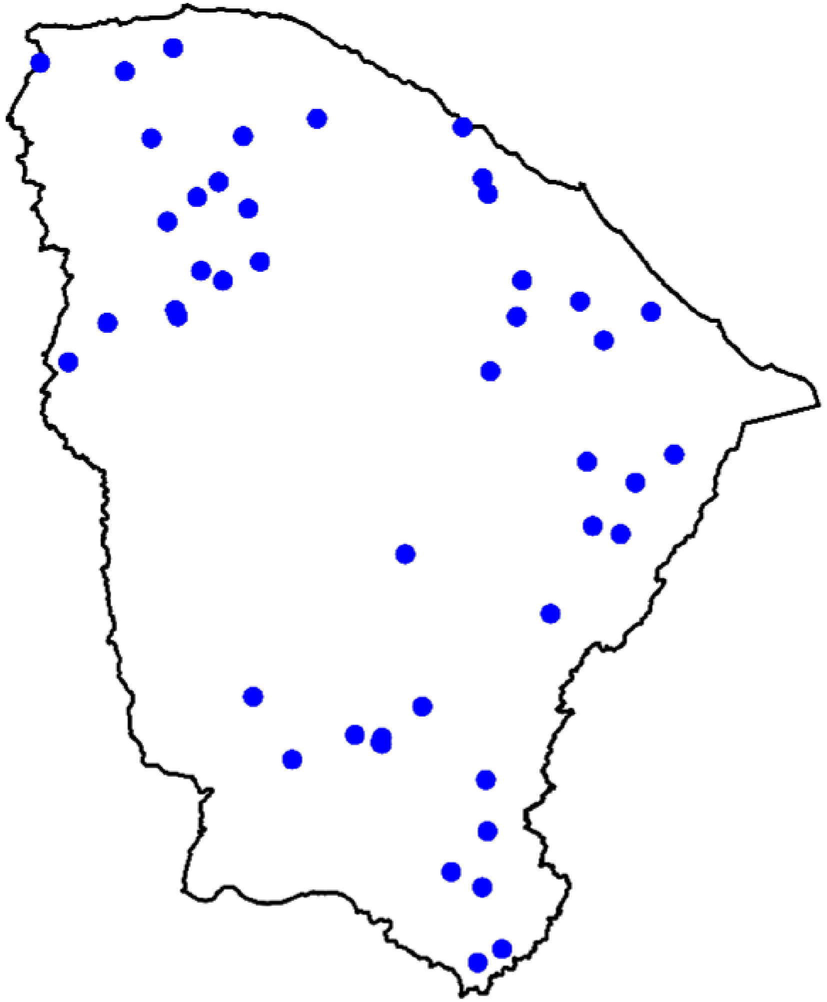
Author: Lira, C. C. S.

Global Surface Water Explorer



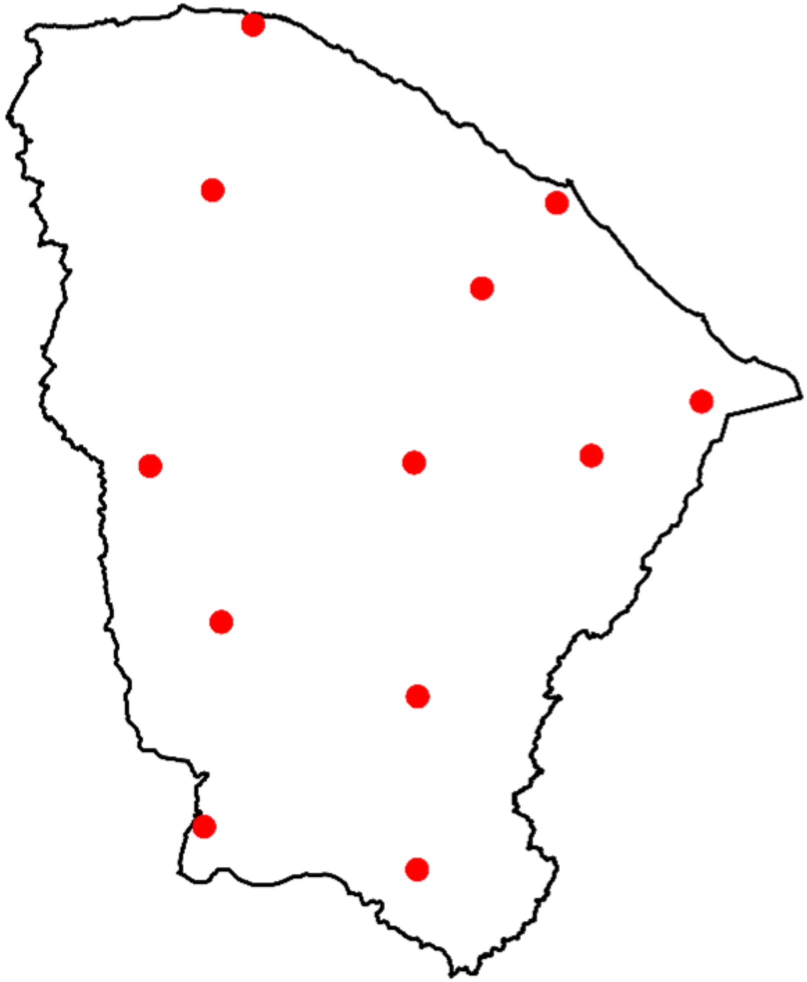
(Pekel et al., 2016) (1984–2021) processed by Pereira et al. (2019) for reservoir geometry information.

ANA river measurement stations



Daily streamflow time series from 37 stations, with Coefficient of Variation (CV) from Nascimento and Medeiros (2017)

INMET Piché evaporimeter



Mean monthly evaporation (Piché evaporimeter) during the dry season (July–December) from the 1981–2010 climatological normals.

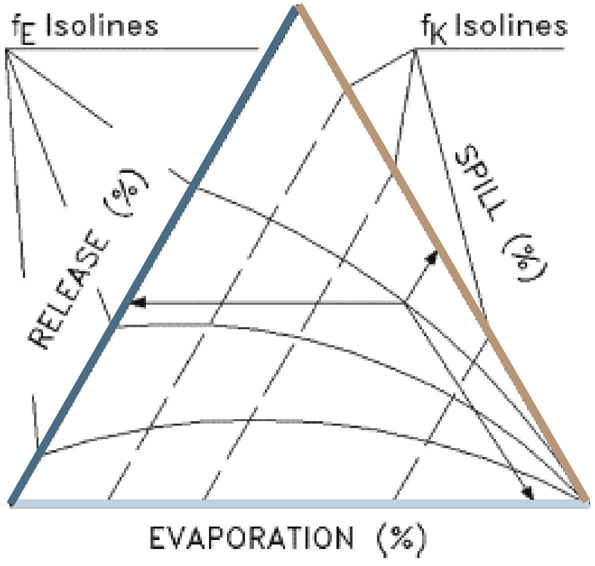
(i) Database

(ii) Hydrological model

(iii) Spatial analysis

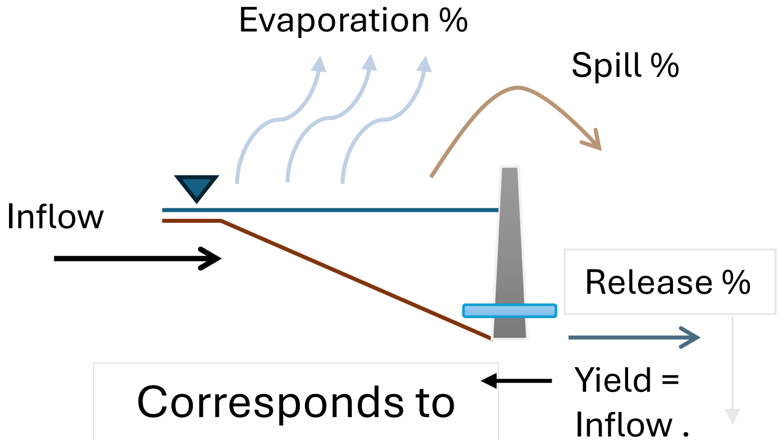
(iv) Roles

Triangular Regulation Diagram (TRD)

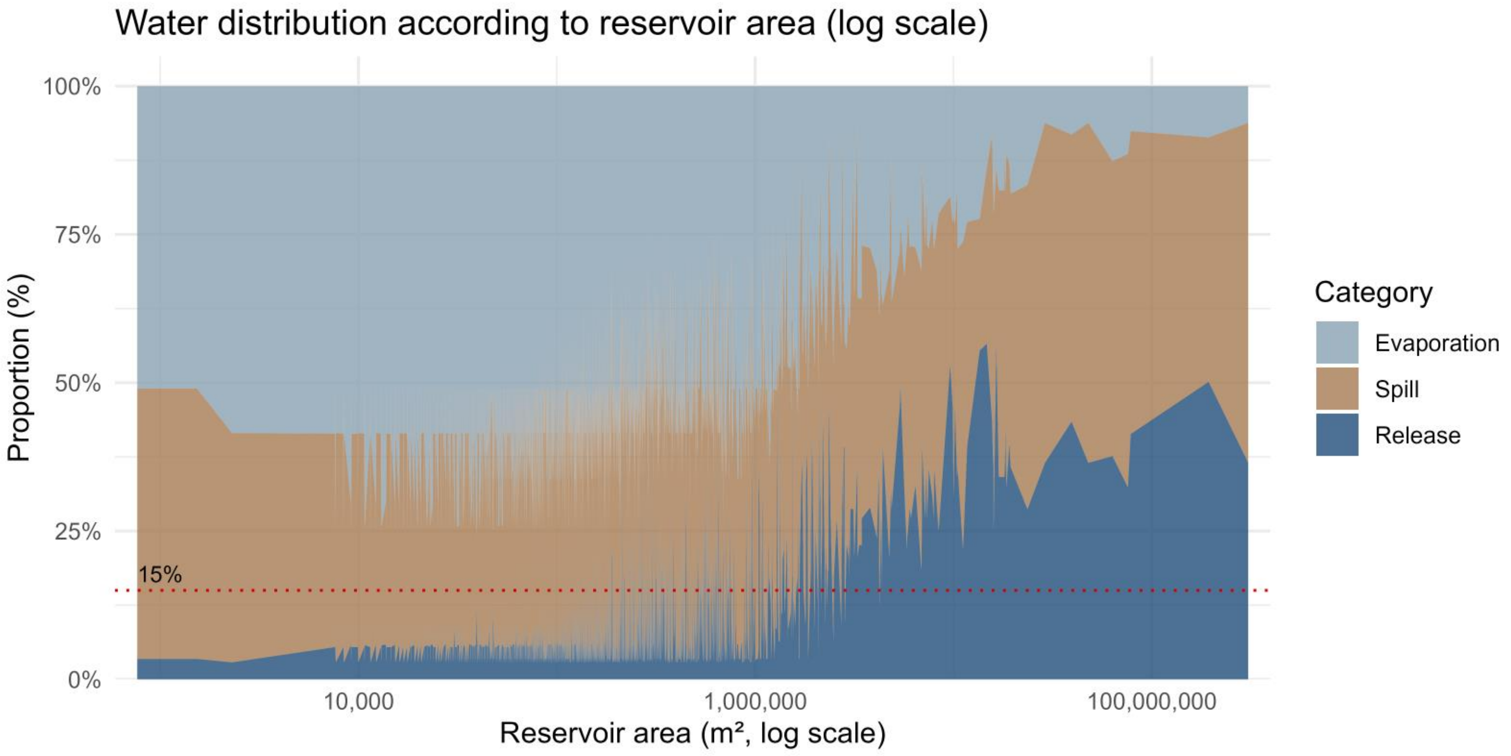


A procedure for reservoir sizing on intermittent rivers under high evaporation rate.

Source: Campos, 2010.

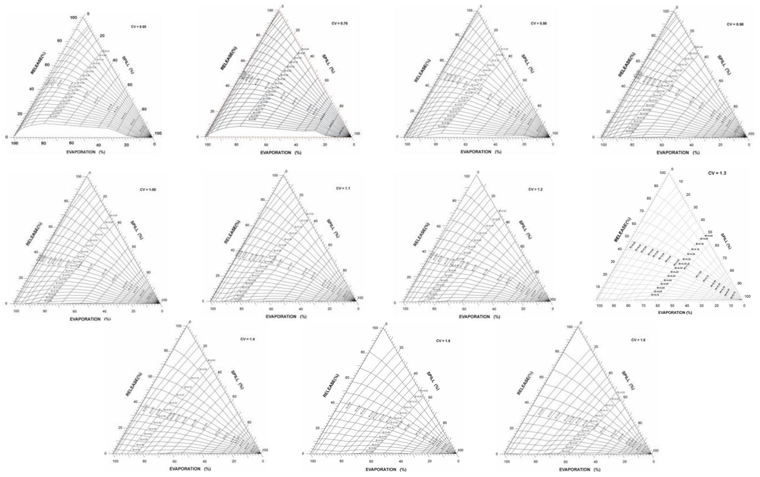


Corresponds to **90% reliability**

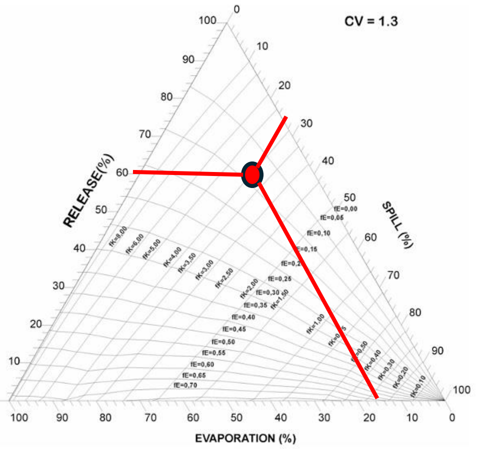


Calculation Methodology

1) Hydrological regime evaluation:



2) Application:

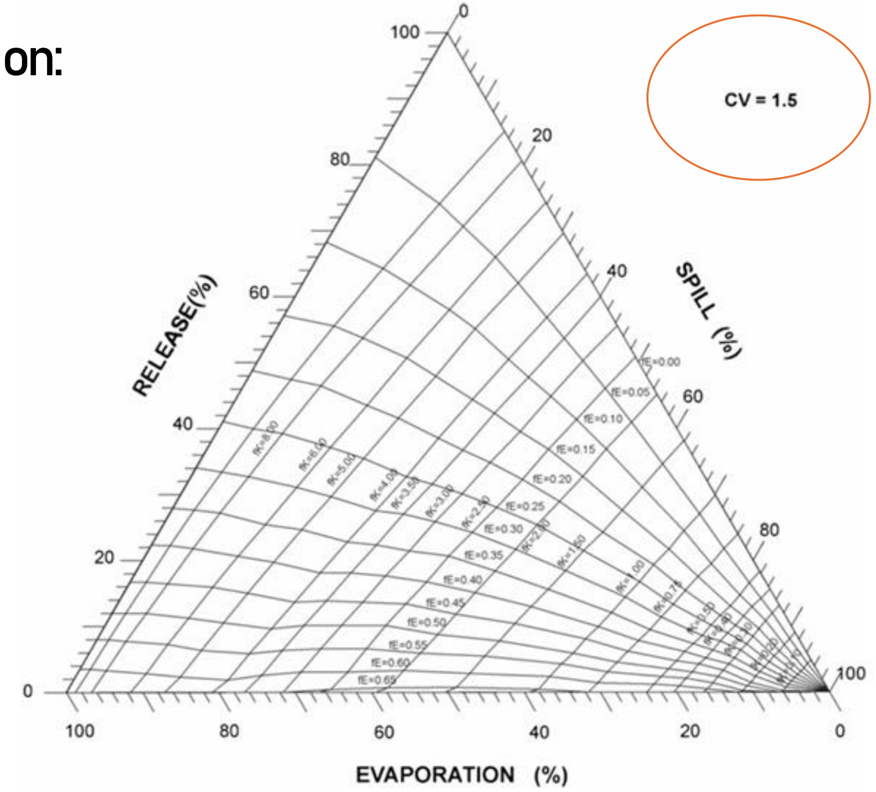


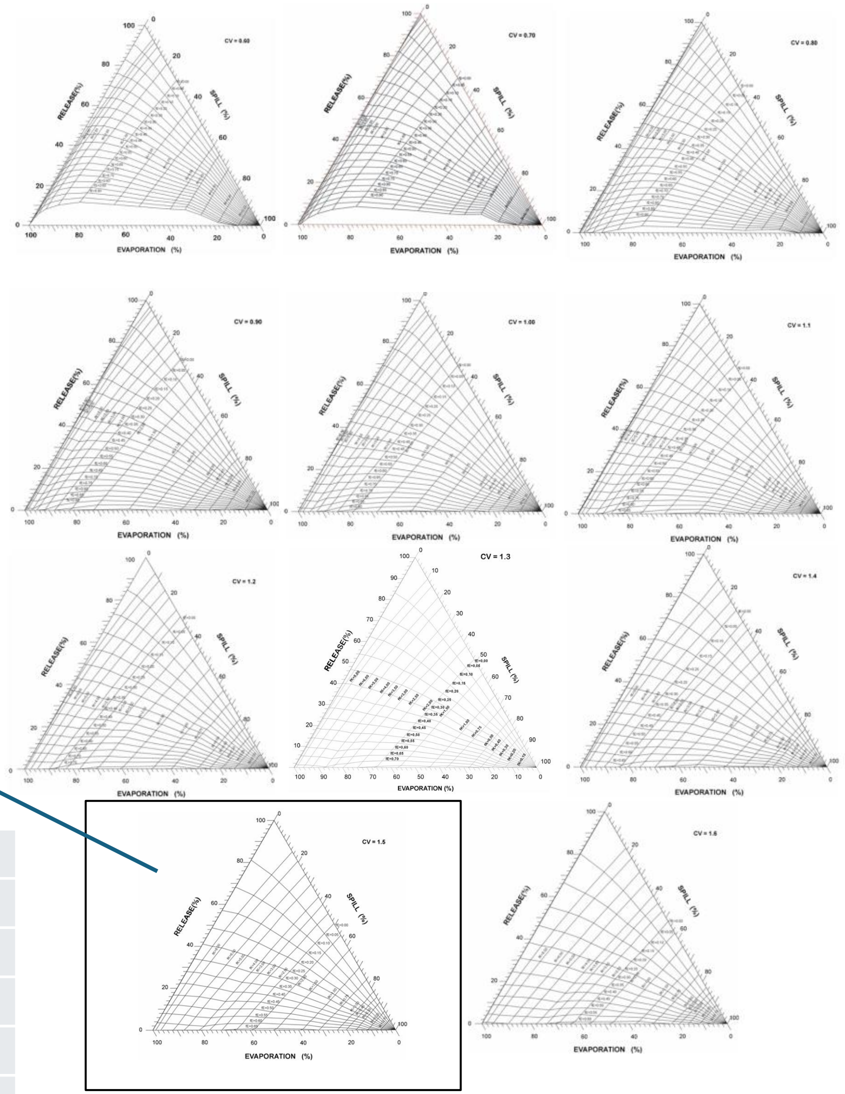
Author: Lira, C. C. S.

1) Hydrological regime evaluation:

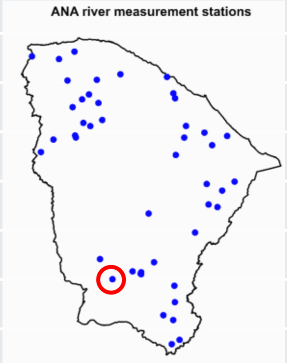
Coefficient of variation

$$\mu = annual\ mean, Cv = \frac{\nu}{\mu}$$





ANO	JAN	FEV	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ	Year	
2006	0,31	0,54	0,82	1,32	2,00	0,18	0,06	0,03	0,09	0,19	0,32	0,25	6,113906	
2007	0,25	1,06	0,44	0,21	0,22	0,07	0,06	0,02	0,16	0,26	0,47	0,50	3,7125	
2009	1,00	1,49	1,48	7,82	35,51	13,02	0,16	0,18	0,21	0,29	0,35	0,40	61,89812	
2011	1,46	0,69	2,14	1,24	0,25	0,11	1,33	0,56	0,54	0,46	0,34	0,40	9,518258	
2012	0,54	0,88	0,63	0,55	0,49	0,44	0,35	0,39	0,35	0,42	0,36	0,44	5,847413	
2013	0,47	0,68	0,63	0,57	0,50	0,46	0,35	0,45	0,53	0,58	0,66	1,28	7,170096	
													6,0	
													15,7	AVERAGE
													22,7	STANDARD DEVIATION
													1,45	COEFFICIENT OF VARIATION



Author: Lira, C. C. S.

2) Applicaion:

Trussu: Hydrological & Engineering Data (Cv = 1.3)

- Storage capacity (K): **263 hm^3**
- Mean annual inflow: **73.74 hm^3/year**
- Coeficient of variation (Cv): **1.3**
- Maximum water height (hMAX): **34.5 m**
- Dry-season evaporation (E): **1.11 m**

1) Dimensionless capacity factor (fK):

$$f_K = \frac{Cap}{V_{Inflow}} \qquad f_K = \frac{263}{73.74} = 3.5$$

2) Dimensionless evaporation factor (fE):

i) reservoir opening coeficiente from the elevation-volume curve (K)

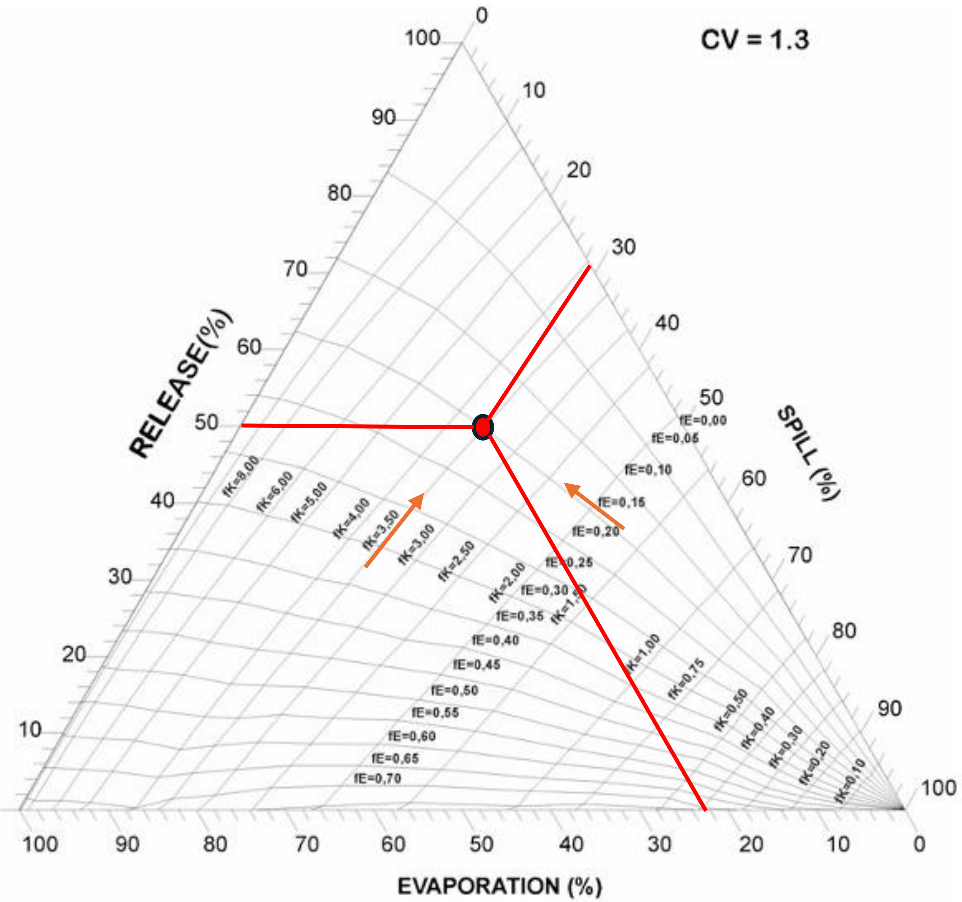
$$k = \frac{V}{{h_{max}}^3} \qquad k = \frac{263}{(34.5)^3} = 6405$$

$$f_E = \frac{3 \cdot K^{1/3} E}{{V_{Inflow}}^{1/3}} \qquad f_E = \frac{3 \,.\, 6405^{1/3} \,.\, 1.11}{73.74^{1/3}} = 0.15$$

Component	% of μ	Annual Volume (hm^3/yr)
Mean Release (E{D})	**50%**	**50% x 73.74 = 36.87**
Mean Spill (E{SP})	27%	19.91
Mean Evaporation (E{EV})	23%	16.96

RTD yield corresponds to **90% reliability**.

From intersection of isolines fK = 3.5 and fE = 0.15:



3) Final Calculation of Yield

- 90% of years → full release **Y**
- 10% of years → average release **Y/2**

  ϕ=0.90+0.10/2=0.95

Y=E{D} **/** ϕ

Y =36.87 **/** 0.95 = 38.81 hm^3/yr

(i) Database

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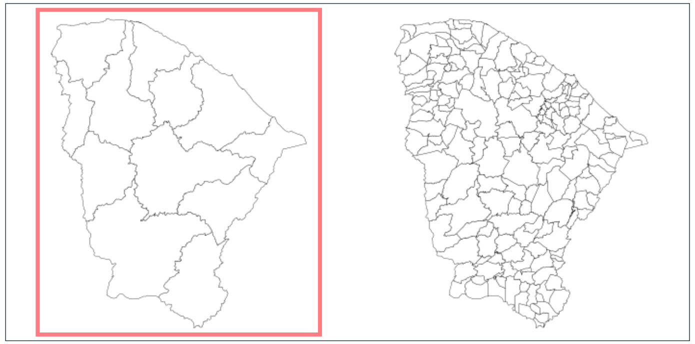


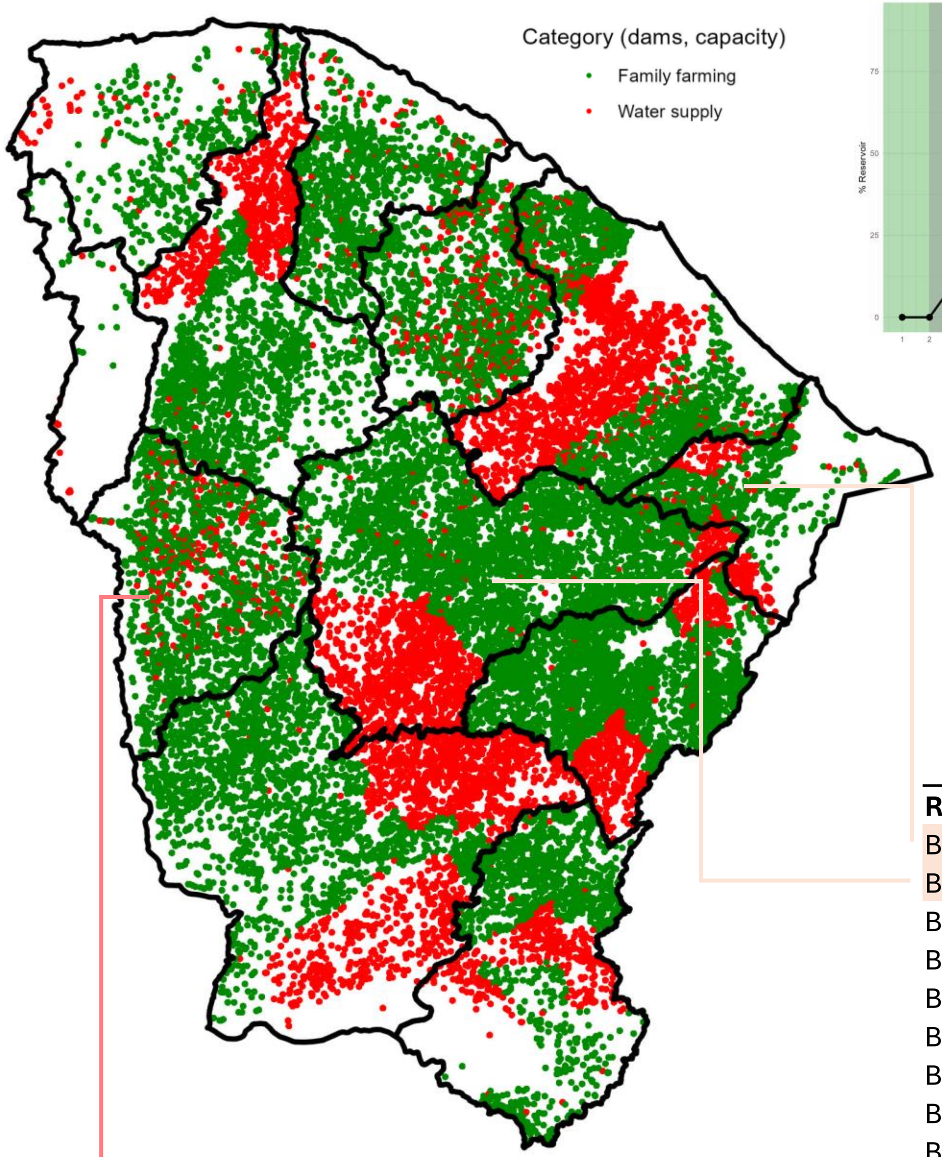
Administrative hydrological watersheds

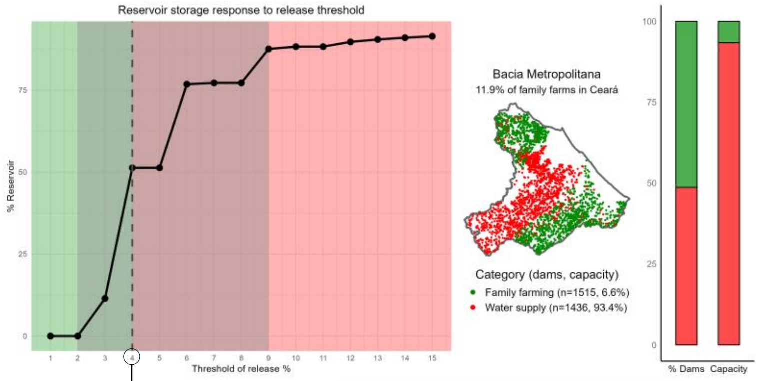
Smaller reservoirs
Lower efficiency

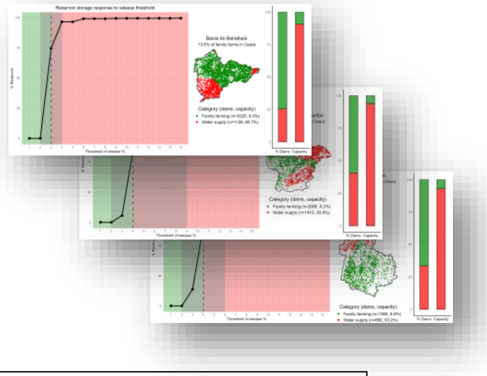
Analysis of the spatial gain of reservoirs with a release rate of less than 15%

Larger reservoirs
High efficiency

Reservoirs with a flow rate of at least 15% of the inflow.







REGIAO	Threshold
Bacia do Baixo Jaguaribe	3
Bacia do Banabuiú	3
Bacia do Alto Jaguaribe	4
Bacia do Acaraú	4
Bacia do Curu	4
Bacia do Medio Jaguaribe	4
Bacia Metropolitana	4
Bacia do Coreaú	6
Bacia do Litoral	6
Bacia do Salgado	6
Bacia da Serra da Ibiapaba	6
Bacia dos Sertão de Crateús	9

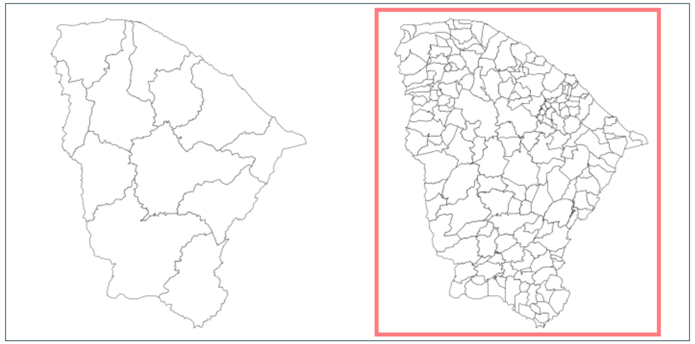
Author: Lira, C. C. S.

(i) Database

(ii) Hydrological model

(iii) Spatial analysis

(iv) Roles

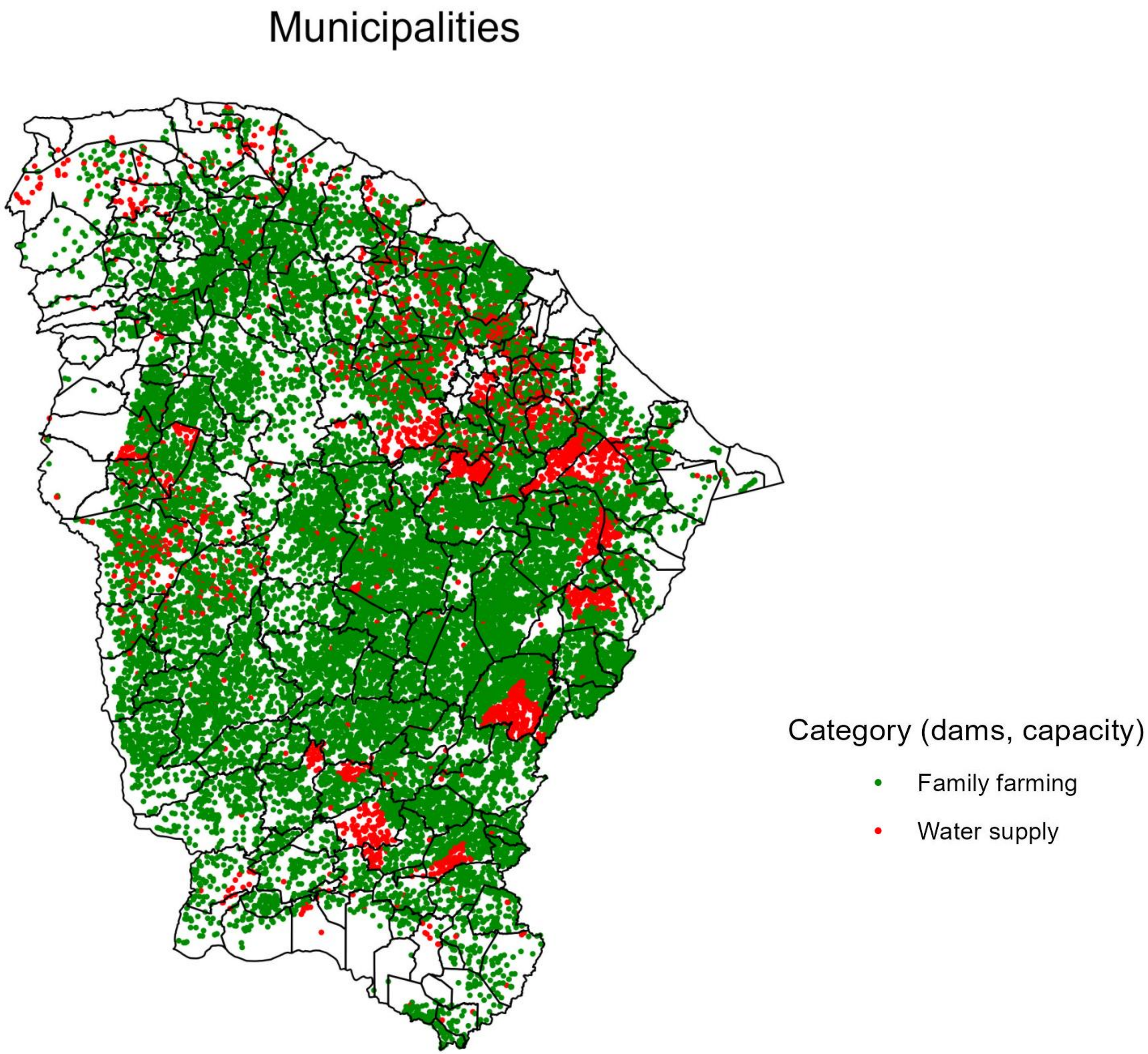


Smaller reservoirs
Lower efficiency

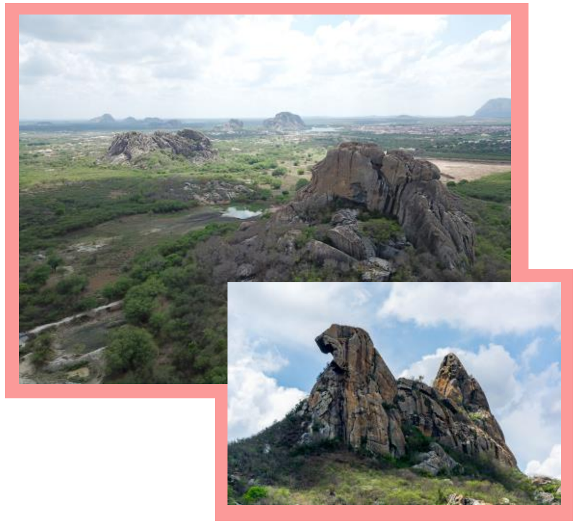
Analysis of the spatial gain of reservoirs with a release rate of less than 15%

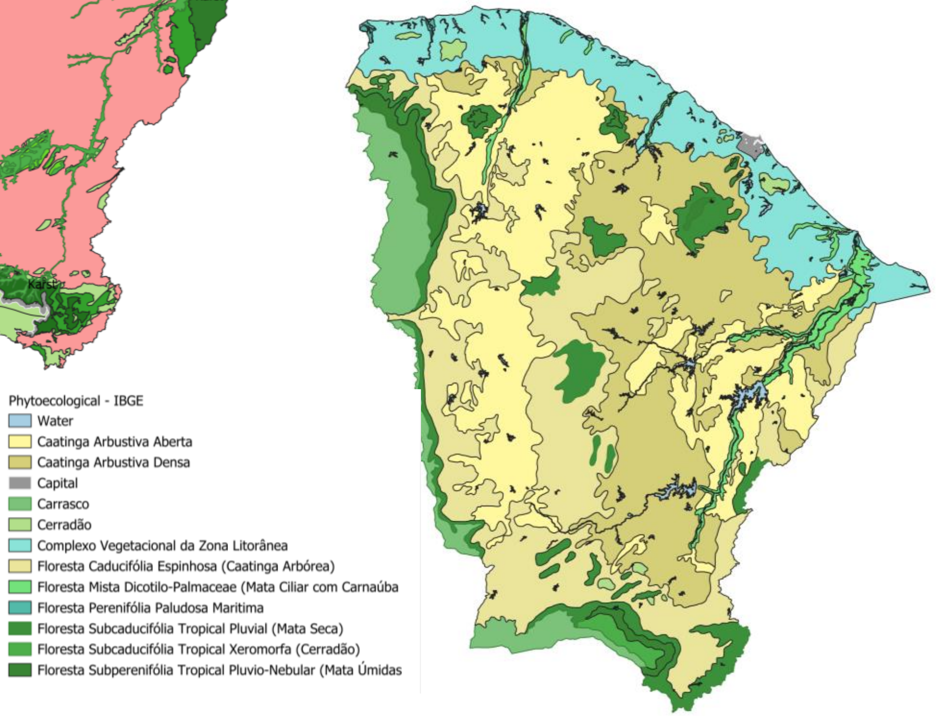
Larger reservoirs
High efficiency

Reservoirs with a flow rate of at least 15% of the inflow.



Hydrogeological Units and Vegetation





Author: Lira, C. C. S.

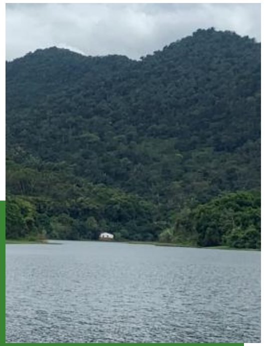
Caatinga

Predominant xerophilous vegetation, with plants adapted to water scarcity (mandacaru, xique-xique).

Carnaubal

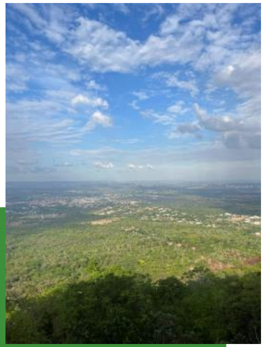
Dominated by the carnauba palm, economically important and for soil protection and water recharge.

Humid Mountain Forests



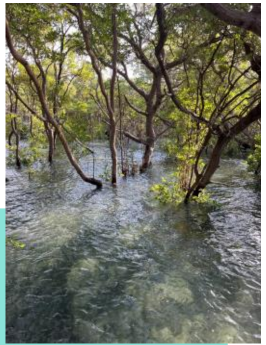
In high-altitude areas, with a more humid climate, they are ecological refuges of great biodiversity.

Cerrado



In localized areas such as the Chapada do Araripe, with grasses and twisted shrubs.

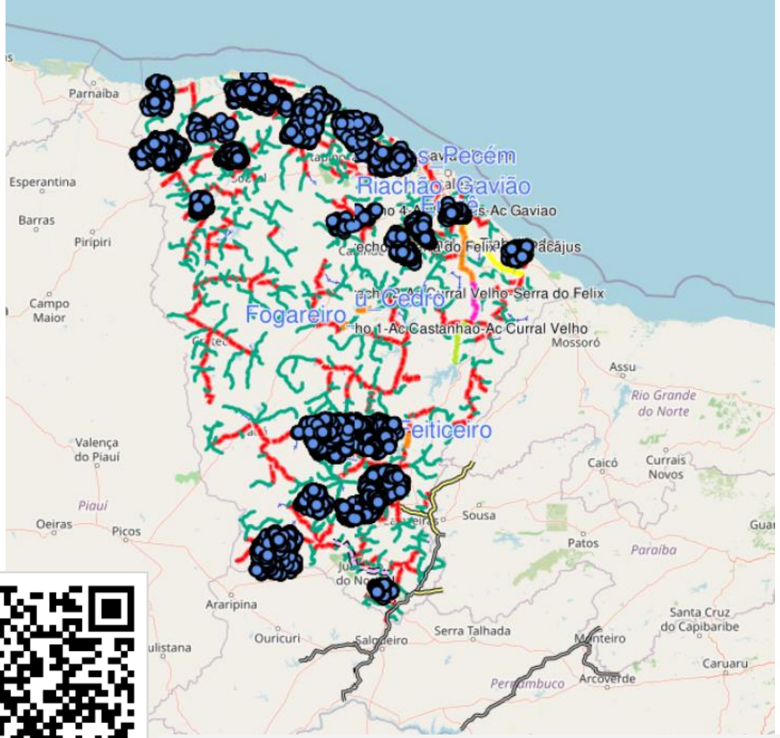
Coastal Vegetation



Restingas and mangroves protect the coast and are nurseries for marine species.

Hydrology and Infrastructure: Overcoming Scarcity in Ceará

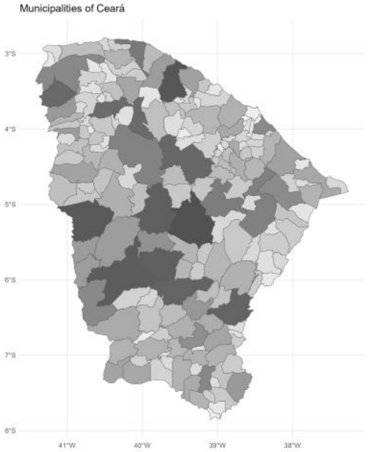
- **Water storage policies**
Ceará's history is marked by the struggle against droughts, driving the creation of a robust water infrastructure, projects such as the Cedro and Castanhão dams.
- **Water transfer projects**
Works like the Canal do Trabalhador, Malha D'Água, CAC, and the São Francisco River Transposition move water to areas with scarcity.
- **Local water solutions**
Cisterns store rainwater for communities, while desalination provides drinking water in dry and coastal regions.

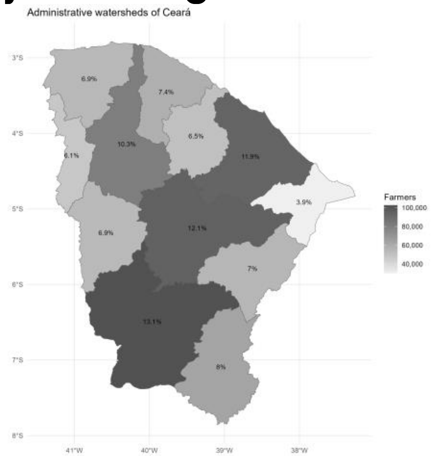


All infrastructure can be viewed on the COGERH Atlas, the official website of the Ceará Water Resources Management Company: http://atlas.cogerh.com.br/

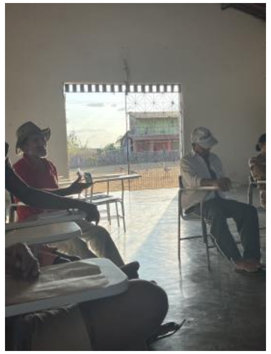
Author: Lira, C. C. S.

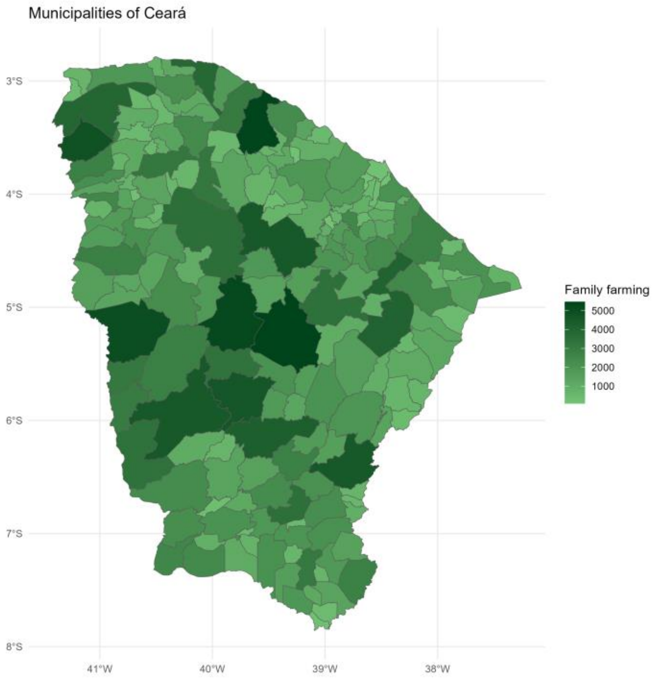
Family Farming in the Semi-Arid Region: Production Practices and Social Organization

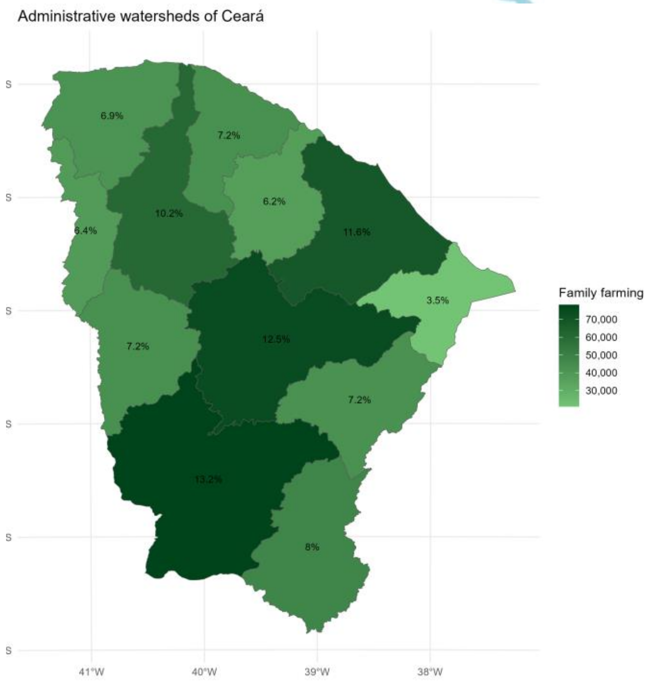




Agricultural enterprises (Database – IBGE) Total: 782,927







Total number of family farming enterprises: 594,405 (76%)

•Main current production systems
Rainfed farming depends on rainfall and includes crops such as corn, beans, cassava, and sorghum, while low-lying humid areas allow cultivation of vegetables, fruits, and forage due to greater soil moisture retention.

•Sustainable practices
Agroecology, rainwater harvesting (cisterns), low-cost irrigation techniques, and drought-resistant crops help improve resilience and reduce environmental impacts.

•Social organization (MST)
The Landless Workers' Movement (MST) promotes land reform, supports family farming, encourages agroecological production, and strengthens rural settlements through collective work and education.

Author: Lira, C. C. S.

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- Candido Portinari. *Dead Child*. 1944, oil on canvas.

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